

SPECIFICATION

METHOD OF MANUFACTURING MAGNETIC RECORDING MEDIUM SUBSTRATE AND MAGNETIC RECORDING MEDIUM

TECHNICAL FIELD

[0001] The present invention relates to a method of manufacturing a magnetic recording medium substrate used in a magnetic disk recording apparatus, and a magnetic recording medium in which the magnetic recording medium substrate prepared by the method is used.

BACKGROUND

[0002] A glass substrate or an aluminum substrate is used in a magnetic disk recording apparatus installed in a computer such as a hard disk drive or the like. A magnetic recording medium is prepared by forming a magnetic film on a glass substrate or an aluminum substrate, and the magnetic film is magnetized with a magnetic head to record information in the magnetic recording medium.

[0003] A magnetic head to record information in a magnetic recording medium or to read recorded information is designed to move while it is floating above the substrate of the magnetic recording medium. When the magnetic recording medium has a concave-convex surface, the magnetic head collides with the concave-convex during moving of the magnetic head, resulting in damages of the magnetic head and the magnetic recording medium. In order to avoid occurrence of such the problem, the surface of the substrate used for the magnetic recording medium is subjected to a high-accuracy polishing treatment so as to make the surface to be smooth, whereby generation of the concave-convex of the surface is suppressed.

[0004] Herein, a conventional method of manufacturing a glass substrate used for a magnetic recording medium by polishing the glass substrate will be described (Patent Document 1, for example). First, a glass material is melted (glass-melting step), and the molten glass is sandwiched with dies after casting the molten glass in the die in the form of a planar surface to prepare a disk-shaped glass substrate (press-molding step). A circular through-hole is formed in a central portion of the glass substrate surface employing a diamond-core drill to prepare a torus-shaped glass substrate (coring step).

[0005] Thereafter, the torus-shaped glass substrate is subjected to a grinding processing with a double face polishing machine holding a plate onto which diamond pellets are attached (first lapping step). In

the first lapping step, both surfaces of the glass substrate are subjected to a grinding processing to preliminarily adjust parallelism, flatness and thickness of the glass substrate.

[0006] The glass substrate whose parallelism is preliminarily adjusted is subjected to grinding and chamfering the outer circumferential edge face of the glass substrate and the inner circumferential edge face of the through-hole to finely adjust the outer diameter dimension and circularity of the glass substrate, and the inner diameter of the through-hole. (edge face-grinding step). The glass substrate for which the outer diameter dimension and so forth are finely adjusted is subjected to polishing the outer circumferential edge face and the inner circumferential edge face to mirror-finish the edge faces (edge face-polishing step).

[0007] The glass substrate whose edge face is subjected to grinding both surfaces again to finely adjust parallelism, flatness and thickness of the glass substrate (second lapping step). The glass substrate whose parallelism and so forth are finely adjusted is subjected to polishing both surfaces thereof to uniform the concave-convex surface (polishing step). In the polishing step, damage of the glass substrate caused by grinding in the lapping steps is removed (first polishing step), and damage remaining in the first polishing step is removed (second polishing step). Then, the glass substrate having been subjected to polishing is used as a magnetic recording medium substrate.

[0008] On the other hand, as to an aluminum substrate, after grinding the substrate surface, a NiP layer is formed on the substrate surface via nonelectrolytic plating. Similarly to a glass substrate, the NiP layer is subjected to polishing via a plurality of polishing steps to smooth the resulting surface (Patent Document 2, for example).

[0009] Then, A magnetic material is formed on a glass substrate or an aluminum substrate whose surface has been polished, via sputtering or the like to prepare a magnetic recording medium.

Patent Document 1: Japanese Patent O.P.I. Publication No. 2003-36522

Patent Document 2: Japanese Patent Examined Publication No. 2001-207161

DISCLOSURE OF THE INVENTION

PROBLEMS TO BE SOLVED BY THE INVENTION

[0010] However, in order to prepare a glass substrate or an aluminum substrate having the smooth surface, a plurality of polishing steps as described above had to be conducted. As a result, there appeared time and cost required for polishing. Further, a substrate having a surface smoother than before is demanded for a high density trend to increase recording density of a magnetic recording medium thereof.

[0011] The present invention solves the above-described problem. It is an object of the present invention to provide a method of manufacturing a magnetic recording medium substrate capable of improving smoothness of the magnetic recording medium substrate even though a part of polishing steps is skipped.

MEANS TO SOLVE THE PROBLEMS

[0012] Structure 1 of the present invention: A method of manufacturing a magnetic recording medium substrate, comprising the steps of polishing a surface of a disk-shaped substrate, and forming a metal oxide film on the substrate surface having been subjected to the polishing step via a liquid phase deposition process to prepare the magnetic recording medium substrate.

[0013] Structure 2 of the present invention: The method of structure 1, comprising the step of polishing the substrate surface in the polishing step until surface roughness Ra reaches 0.3 – 5 nm.

[0014] Structure 3 of the present invention: The method of Structure 1 or 2, wherein the metal oxide film is a silicon dioxide film.

[0015] Structure 4 of the present invention: The method of Structure 1 or 2, wherein the metal oxide film is an oxide film comprising at least one selected from the group consisting of Si, Ti, V, Mn, Ni, Zn, Ge, Y, Zr, Nb, Sn, Sb, Ba, Ta and W.

[0016] Structure 5 of the present invention: The method of any one of Structures 1 – 4, wherein the substrate is a glass substrate or an aluminum substrate.

[0017] Structure 6 of the present invention: The method of any one of Structures 1 – 5, wherein the step of forming the metal oxide film comprises the processes of immersing the substrate having been subjected to the polishing step in an aqueous solution, and hydrolyzing a metal-fluoro complex in the aqueous solution to form the metal oxide film on the surface of the substrate having been subjected to the polishing step.

[0018] Structure 7 of the present invention: A magnetic recording medium comprising a disk-shaped substrate having a surface roughness Ra of 0.3 – 5 nm, a metal oxide film formed on a surface of the substrate, and a magnetic film further formed on the metal oxide film.

EFFECT OF THE INVENTION

[0019] In the present invention, smoothness of the surface of a magnetic recording medium substrate becomes possible to be improved by forming a metal oxide film on the substrate surface via a liquid

phase deposition process. By doing this, the smoothness required for a substrate utilized for a magnetic recording medium can be acquired even though a part of polishing steps is skipped.

BRIEF DESCRIPTION OF THE DRAWINGS

[0020] Fig. 1 is a perspective illustration of a magnetic recording medium substrate relating to an embodiment of the present invention.

Fig. 2 is a cross-sectional view of a magnetic recording medium substrate relating to an embodiment of the present invention, and shows a II – II cross-sectional view in Fig. 1.

Figs. 3a and 3b each are a cross-sectional view showing a partial cross section of a magnetic recording medium substrate relating to an embodiment of the present invention.

Figs. 4a, 4b and 4c each are a cross-sectional view in which a partial cross section of a magnetic recording medium substrate relating to an embodiment of the present invention is enlarged.

EXPLANATION OF NUMERALS

- [0021]
- 1 Magnetic recording medium substrate
 - 2 Substrate
 - 3 Metal oxide film
 - 4 Polishing trace
 - 21 Through-hole
 - 22, 23 Surface
 - 41, 42 Groove

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0022] The magnetic recording medium substrate relating to an embodiment of the present invention will be described referring to Fig. 1 and Fig. 2. Fig. 1 is a perspective illustration of a magnetic recording medium substrate relating to an embodiment of the present invention, and Fig. 2 is a cross-sectional view of a magnetic recording medium substrate relating to an embodiment of the present invention, showing a II – II cross-sectional view in Fig. 1.

[0023] As shown in Fig. 1 and Fig. 2, the magnetic recording medium substrate in the present embodiment possesses circular disk-shaped substrate 2. Through-hole 21 passing through in the thickness direction of substrate 2 is formed in a central portion of the substrate. Further, Metal oxide film 3 is formed on the surface of substrate 2.

[0024] A glass substrate or an aluminum substrate is used as substrate 2. Size of substrate 2 is specifically limited, and a 0.85 inch size substrate, a 1 inch size substrate, a 2.5 inch size substrate or a 3.5 inch size substrate is utilized. Further, soda-lime glass, aluminosilicate glass, lithium silicate glass and boron silicate glass having been prepared via a method such as a float method, a press method or the like are employed for a glass substrate.

[0025] An oxide film containing at least one selected from the group consisting of Si, Ti, V, Mn, Ni, Zn, Ge, Y, Zr, Nb, Sn, Sb, Ba, Ta and W is used for metal oxide film 3.

[0026] A magnetic film is formed on the surface of magnetic recording medium substrate 1 via sputtering to prepare a magnetic recording medium.

[0027] Next, a method of manufacturing magnetic recording medium substrate 1 will be described. In the present embodiments, the case of manufacturing magnetic recording medium substrate 1 employing a glass substrate as substrate 2 will be described.

[0028] First, similarly to a conventional technique, a glass material is melted (glass-melting step), and the molten glass is sandwiched with dies after casting the molten glass in the die in the form of a planar surface to prepare a disk-shaped glass substrate (press-molding step). When the surface of this glass substrate was evaluated after conducting this press-molding step, a surface roughness Ra of the glass substrate of $0.1 - 2.0 \mu\text{m}$ and a maximum height Rmax of $0.5 - 10.0 \mu\text{m}$ were obtained. A circular through-hole is formed in a central portion of the glass substrate surface employing a diamond-core drill to prepare a torus-shaped glass substrate (coring step).

[0029] Thereafter, the torus-shaped glass substrate is subjected to a grinding processing with a double face polishing machine holding a plate onto which diamond pellets are attached (first lapping step). In the first lapping step, both surfaces of the glass substrate are subjected to a grinding processing to preliminarily adjust parallelism, flatness and thickness of the glass substrate. When the surface of the glass substrate is evaluated after conducting the first lapping step, a surface roughness Ra of the glass substrate of $0.1 - 0.5 \mu\text{m}$ is obtained, and a maximum height Rmax of the glass substrate of $0.5 - 5.0 \mu\text{m}$ is also obtained. In other words, the surface of the glass substrate is ground until surface roughness Ra and maximum height Rmax reach $0.1 - 0.5 \mu\text{m}$ and $0.5 - 5.0 \mu\text{m}$, respectively.

[0030] The glass substrate whose parallelism is preliminarily adjusted is subjected to grinding the outer circumferential edge face of the glass substrate and the inner circumferential edge face of the through-hole (edge face-grinding step), and further subjected to polishing the outer circumferential edge face and the inner circumferential edge face to mirror-finish the edge faces (edge face-polishing step).

[0031] The glass substrate whose edge face is subjected to grinding both surfaces again to finely adjust parallelism, flatness and thickness of the glass substrate (second lapping step). When the surface of the glass substrate is evaluated after conducting the second lapping step, a surface roughness R_a of the glass substrate of $0.05 - 0.2 \mu\text{m}$ is obtained, and a maximum height R_{max} of the glass substrate of $0.3 - 2.0 \mu\text{m}$ is also obtained. In other words, the surface of the glass substrate is ground until surface roughness R_a and maximum height R_{max} reach $0.1 - 0.5 \mu\text{m}$ and $0.5 - 5.0 \mu\text{m}$, respectively.

[0032] The glass substrate whose parallelism and so forth are finely adjusted is subjected to polishing both surfaces thereof (polishing step). When the surface of the glass substrate is evaluated after conducting the polishing step, a surface roughness R_a of the glass substrate of $0.3 - 5 \mu\text{m}$ is obtained, and a maximum height R_{max} of the glass substrate of $2.0 - 200 \mu\text{m}$ is also obtained. In other words, the surface of the glass substrate is ground until surface roughness R_a and maximum height R_{max} reach $0.3 - 5 \mu\text{m}$ and $2.0 - 200 \mu\text{m}$, respectively. The substrate after conducting this polishing step corresponds to substrate 2.

[0033] In the polishing step, a commonly known polishing machine is employed, and both surfaces of the glass substrate are polished employing formed urethane or a suede abrasive cloth. A polishing material employed in the polishing step is to be used so as to slurry cerium oxide particles. For example, polishing is carried out employing cerium oxide particles having an average particle size of roughly $0.5 \mu\text{m}$.

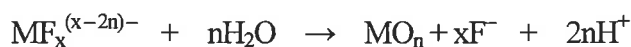
[0034] In the present invention, a metal oxide film is formed on the surface of the glass substrate (substrate 2) after conducting the polishing step. This film-forming step will be described referring to Fig. 3. Fig. 3 is a cross-sectional view showing a partial cross section of a magnetic recording medium substrate relating to an embodiment of the present invention.

[0035] Substrate 2 after conducting the polishing step is shown in Fig. 3a. Groove-shaped polishing trace 4 which has not been removed in the lapping steps and the polishing step remains on surface 22 and surface 23 of substrate 2. As described above, substrate 2 after conducting the polishing step has a surface roughness R_a of $0.3 - 5 \text{ nm}$ and a maximum height R_{max} of $2.0 - 200 \text{ nm}$.

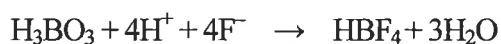
[0036] And, as shown in Fig. 3b, metal oxide film 3 is formed on surface 22 and surface 23 of substrate 2. In the present embodiment, metal oxide film 3 is formed on surface 22 and surface 23 of substrate 2 via a liquid phase deposition process by which a metal oxide film is deposited from a liquid phase to prepare magnetic recording medium substrate 1. Specifically, substrate 2 is immersed in an aqueous solution to form metal oxide film 3 on surface 22 and surface 23 of substrate 2.

[0037] The liquid phase deposition process is a process by which metal oxide film 3 is directly formed on substrate 2 by utilizing equilibrium reaction of a metal-fluoro complex in an aqueous solution. This reaction can be represented by the following chemical formulae.

Chemical reaction formula (1)



Chemical reaction formula (2)



Chemical reaction formula (1) exhibits the main reaction, and symbol M represents a metal.

[0038] The metal-fluoro complex is hydrolyzed to produce a metal oxide. In this case, as shown in chemical reaction formula (2), fluoride ions are consumed by adding a boric acid into the system. When the fluoride ions are consumed, the equilibrium reaction in chemical reaction formula (1) is shifted to the right side, whereby deposition reaction of the metal oxide is accelerated. As shown in Fig. 3b, uniform metal oxide film 3 is formed on surface 22 and surface 23 of substrate 2.

[0039] In this way, smoothness of the surface of magnetic recording medium substrate 1 can be improved by forming metal oxide film 3 on surface 22 and surface 23 of substrate 2 via a liquid phase deposition process. That is, the surface of magnetic recording medium substrate 1 can be smoothed by filling the metal oxide film deposited by a liquid phase deposition process in polishing trace 4 remaining on surface 22 and surface 23 of substrate 2. Magnetic recording medium substrate 1 obtained by forming metal oxide film 3 on the surface of magnetic recording medium substrate 1 can be arranged to have a surface roughness Ra of 0.1 – 0.3 nm and a maximum height Rmax of 1.0 – 10.0 nm.

[0040] As described above, in the present embodiment, the smoothness can be obtained by forming metal oxide film 3 on the surface of substrate 2 to such an extent that surface roughness Ra of magnetic recording medium substrate 1 reaches a level desired for a magnetic recording medium. As a result, a part of the polishing steps in the manufacturing steps of magnetic recording medium substrate 1 can be skipped, whereby polishing cost and time consumed for polishing are possible to be reduced.

[0041] As to a magnetic recording medium, a flying height as a head-floating height from the surface of the medium is lowered to increase the recording density, and it is, for example, a height of 10 nm or less. For this reason, a magnetic recording medium is constantly desired to have a very smooth surface having a surface roughness Ra of several angstroms or preferably much smaller. In the present embodiment, since magnetic recording medium substrate 1 can be arranged to have a surface roughness Ra of 0.1 – 0.3 nm by forming metal oxide film 3, it is applicable to a magnetic recording medium to be applied to a very low flying height of 10 nm or less.

[0042] In order to smooth the surface of a magnetic recording medium substrate, the second polishing step was conventionally carried out as the final polishing step. That is, the glass substrate after conducting the first polishing step was polished to such an extent that surface roughness R_a reached a level desired for a magnetic recording medium. The glass substrate after conducting the first polishing step was subjected to the second polishing step until surface roughness R_a and maximum height R_{max} reached 0.1 – 0.3 nm and 1.0 – 10.0 nm, respectively. In contrast, in the case of the present embodiment, surface roughness R_a and maximum height R_{max} can reach 0.1 – 0.3 nm and 1.0 – 10.0 nm, respectively without conducting the second polishing step. Thus, the second polishing step is possible to be skipped.

[0043] Further, since substrate 2 is immersed in an aqueous solution, metal oxide film 3 can be formed on the entire surface of substrate 2. That is, metal oxide film 3 can be formed on both surfaces of substrate 2 (surface 22 and surface 23), the inner circumferential edge face of through-hole 21 and the outer circumferential edge face of substrate 2 at the same time. In this way, since metal oxide film 3 can be formed on the entire surface of substrate 2 by a single film-forming step, metal oxide film 3 can be easily formed without increasing the number of film-forming steps. By doing this, film-forming cost and time consumed for film formation can be reduced. Specifically in the case of a hard disk, since both surfaces of a magnetic recording medium are used as a recording region thereof, in the present invention, a magnetic recording medium substrate is possible to be effectively prepared without increasing the number of film-forming steps.

[0044] In the case of a method of forming a film on one surface by one surface of a substrate via dry processing, the substrate tends to be damaged when chucking the substrate, and particle contamination tends to be also produced. In contrast, in the case of the present embodiment, since substrate 2 may be simply immersed in an aqueous solution, possibility to damage the substrate or to produce the particle contamination can be reduced. Further, since substrate 2 may be simply immersed in an aqueous solution, batch processing is allowed to be utilized, and a film-forming process becomes possible to be applied to a plurality of substrates at once. Further, it produces the effect of improving yield of magnetic recording medium substrate 1 to fill microfine defects easily generated at the edge of substrate 2 in with metal oxide film 3.

[0045] Examples of the method of forming a metal oxide film on the surface of substrate 2 in addition to a liquid phase deposition method include a vacuum evaporation method, a sputtering method, a CVD (chemical vapor deposition) method, and a sol-gel method. However, since it is difficult to form a metal oxide film down into polishing trace 4 remaining on the surface of substrate 2 via a so-called

vapor deposition method such as a vacuum evaporation method, a sputtering method or a CVD method, it is difficult to smooth the surface of the magnetic recording medium substrate. Further, since a film-forming apparatus is very expensive, it is difficult to reduce manufacturing cost. Further, a sol-gel method is a convenient method, but voids are generated between the surface of substrate 2 and a sol-gel film, whereby it is difficult to form an excellent metal oxide film. In contrast, in the case of the present embodiment, since a metal oxide film can be formed deep down into polishing trace 4 by forming the film via a liquid phase deposition method, it becomes possible to smooth the surface of magnetic recording medium substrate 1.

[0046] Since in the case of a liquid phase deposition process, a metal oxide film can be formed in a liquid phase at room temperature, aluminum used for substrate 2 is possible to produce the same action and effect as those of glass as a material used for substrate 2. When an aluminum substrate is used as substrate 2, an NiP layer having a thickness of 5 – 8 μm is formed on an aluminum substrate having been subjected to grinding via nonelectrolytic plating. Then, similarly to a glass substrate subjected to polishing, the NiP layer formed on the aluminum substrate is polished until surface roughness Ra and maximum height Rmax reach 0.3 – 5 nm and 2.0 – 200 nm, respectively. Then, similarly to a glass substrate, metal oxide film 3 is formed on the NiP layer via a liquid phase deposition process to prepare a magnetic recording medium substrate. A surface roughness Ra of 0.1 – 0.3 nm and a maximum height Rmax of 1.0 – 10.0 nm can be obtained by filling metal oxide film 3 in polishing traces formed on the NiP layer.

[0047] Herein, a mechanism with which the surface of magnetic recording medium substrate 1 is smoothed by forming metal oxide film 3 will be described referring to Figs. 4a, 4b and 4c. Figs. 4a, 4b and 4c each are a cross-sectional view in which a partial cross section of a magnetic recording medium substrate relating to an embodiment of the present invention is enlarged.

[0048] Fig. 4a shows surface 22 of substrate 2 after conducting the polishing step. Groove-shaped polishing trace 4 remains on surface 22 of substrate 2. In the case of a liquid phase deposition process, a film is deposited via very fine energy difference at the interface caused by equilibrium reaction. For this reason, when metal oxide film 3 is formed on the surface of substrate 2 via a liquid phase deposition process, metal oxide film 3 can be formed at the same film-forming rate without depending on a form, even though having surface 22 formed in the form of grooved-shaped polishing trace 4. And, the shape of metal oxide film 3 follows the shape of surface 22 of substrate 2. For example, as shown in Fig. 4b, when metal oxide film 3 is formed on surface 22 of substrate 2, metal oxide film 3 is formed

down into the inside of polishing trace 4, and groove 41 is formed on metal oxide film 3 so as to follow the shape of polishing trace 4.

[0049] When reaction further proceeds, as shown in Fig. 4c, the groove-shaped form formed on surface 22 of substrate 2 is gradually covered, whereby groove 42 formed on the surface becomes gradually smaller in size. When the reaction further proceeds, metal oxide film 3 is filled in the groove generated by polishing trace 4, whereby the surface of magnetic recording medium substrate 1 becomes smooth. In this way, smoothness desired for the magnetic recording medium substrate is possible to be obtained by forming metal oxide film 3 on the surface of substrate 2 via a liquid phase deposition process,

[0050] Since the shape of polishing trace 4 is almost covered by forming metal oxide film 3 having the same film thickness as the depth of polishing trace 4 on the surface, a film-forming amount of metal oxide film 3 may be controlled, adjusting smoothness of substrate 2.

[0051] In addition, an SiO_2 film or a TiO_2 as metal oxide film 3 is preferably formed. The reason for this is that an SiO_2 film or a TiO_2 can be easily formed since equilibrium reaction can proceed smoothly in an aqueous solution when Si or Ti is employed as a metal.

[0052] A magnetic film is formed on the surface of magnetic recording medium substrate 1 prepared in the foregoing steps to prepare a magnetic recording medium. That is, the magnetic recording medium in the present embodiment possesses metal oxide film 3 formed on the surface of substrate 2 composed of a glass substrate or an aluminum substrate, and a magnetic film formed on metal oxide film 3.

[0053] Further, a soft magnetic layer is formed on the surface of magnetic recording medium substrate 1; an intermediate layer is formed on the soft magnetic layer; and a recording layer composed of a magnetic film may be formed on the intermediate layer. As an example, a soft magnetic layer having a thickness of 5 – 20 nm, which is made of CoZrNb is utilized, and an intermediate layer having a thickness of 10 – 20 nm, which is made of Pt-C is utilized.

[0054] Further, as an example, a magnetic film having a thickness of 10 – 15 nm, which is made of CoCrPt-SiO₂ is utilized. The film may be formed via sputtering, for example. In addition, when an aluminum substrate is used as substrate 2, an NiP layer is formed on the aluminum substrate, and metal oxide film 3 is formed on the NiP layer.

EXAMPLE

[0055] Next, specific examples in the foregoing embodiments will be described.

(Example 1)

(Substrate 2)

In Example 1, dimensions of substrate 2 which is an aluminosilicate glass substrate prepared by a press method are shown below.

[0056] Diameter of substrate 2 = 2.5 inches (62.5 mm)

Inner diameter of substrate 2 (diameter of through-hole 21) = 20 mm

Thickness of substrate 2 = 0.635 mm

(Surface roughness Ra after conducting polishing step)

Substrate 2 is a substrate having been subjected to the first lapping step, the second lapping step and the polishing step which have been described above. In the first lapping step and the second lapping step, weight applied to a glass substrate from a surface plate and the number of rotations of the surface plate were adjusted to polish both surfaces of substrate 2. In the first lapping step and the second lapping step, a weight of 60 g/cm² is used to polish at 10 rpm as the number of rotations of the surface plate. In the polishing step, diamond pellets used in the lapping step were replaced by a pad and a polishing solution to be used. As the pad, formed urethane having a hardness of 80 was used. The abrasive was made in the form of a slurry by dispersing cerium oxide particles having a particle diameter of 0.6 μm in water. The weight applied to a glass substrate from a surface plate, and the number of rotations of the surface plate were set to 90 g/cm² and 25 rpm, respectively. Surface roughness Ra of substrate 2 after conducting the polishing step was measured with an atomic force microscope (AFM). Thus, a surface roughness Ra of substrate 2 of 0.8 nm and a maximum height Rmax of 30.0 nm were obtained.

(Formation of metal oxide film 3)

In Example 1, an SiO₂ film as metal oxide film 3 is formed on the surface of substrate 2. Specifically, substrate 2 after conducting a polishing step was immersed in a mixture solution obtained by mixing 0.5 mol/L of an aqueous (NH₄)₂SiF₆ solution with 0.2 mol/L of an aqueous H₃BO₃ solution at room temperature for one hour. In Example 1, substrate 2 was immersed in a volume of 500 mL of the mixture solution. In addition, when the SiO₂ film is formed on a plurality of substrates at once, substrates 2 may be immersed in a mixture solution after increasing a volume of the mixture solution and circulating the mixture solution.

(Surface roughness Ra after film formation)

An SiO₂ film having a thickness of 30 nm was formed on the surface of substrate 2 via the immersion. Since substrate 2 was immersed in the mixture solution, the SiO₂ film was formed on the

entire surface of substrate 2. A substrate on which this SiO₂ film has been formed corresponds to the foregoing magnetic recording medium substrate 1. Surface roughness Ra of the substrate on which the SiO₂ film was formed was measured, and as a result, a surface roughness Ra of 0.1 nm was obtained.

[0057] As described above, in Example 1, a substrate sufficiently having a smooth surface as a magnetic recording medium substrate can be prepared without conducting the second polishing step, by forming an SiO₂ film on the surface of substrate 2 after conducting a polishing step via a liquid phase deposition process. In other words, surface roughness Ra obtained when the second polishing step was not conducted was possible to be at the same surface roughness level as one obtained when the second polishing step was conducted.

(Example 2)

In Example 2, a glass substrate was used as substrate 2, and the conditions of the polishing step were changed. Specifically, the polishing amount (polishing time) was cut in the polishing step. As a result, a surface roughness Ra of substrate 2 of 5 nm and a maximum height Rmax of 200 nm were obtained. Then, an SiO₂ film having a thickness of 200 nm was formed on the surface of this substrate 2 by the same method as in Example 1. A substrate on which this SiO₂ film has been formed corresponds to the foregoing magnetic recording medium substrate 1. The substrate on which the SiO₂ film was formed had a surface roughness Ra of 0.1 nm.

[0058] As described above, since the surface of magnetic recording medium substrate 1 can be smoothed by forming an SiO₂ film roughly having the same film thickness as the depth of polishing trace 4, the polishing amount (polishing time) is possible to be cut in a polishing step.

(Example 3)

In Example 3, an aluminum substrate was used as substrate 2. Since the dimensions of substrate 2 are the same dimensions as in Example 1, the description will be omitted.

[0059] The surface of substrate 2 was ground, and an NiP layer was formed on its surface via nonelectrolytic plating. In Example 3, an NiP layer having a thickness of 5 μm was formed. Then, similarly to the case of polishing with respect to a glass substrate, the NiP layer having been formed on substrate 2 was polished. Surface roughness Ra of substrate 2 after polishing, and maximum height Rmax were obtained to be 0.8 nm and 30.0 nm, respectively.

[0060] Thereafter, substrate 2 was immersed in the same mixture solution as in Example 1. Then, an SiO₂ film having a thickness of 30 nm was formed on a NiP layer. A substrate on which this SiO₂ film has been formed corresponds to the foregoing magnetic recording medium substrate 1. Surface

roughness Ra of the substrate on which the SiO₂ film was formed was measured, and as a result, a surface roughness Ra of 0.1 nm was obtained.

[0061] As described above, in the case of Example 2 and Example 3, similarly to Example 1, each of substrates having sufficiently smooth surface was able to be prepared as a magnetic recording medium substrate.

[0062] In addition, in Example 1, Example 2 and Example 3 as described above, surface roughness Ra of substrate 2 after conducting the polishing step was 0.8 nm or 5.0 nm, but the same effect can be produced even though surface roughness Ra is other than one having each of these values. For example, when surface roughness Ra obtained after conducting the polishing step is 0.3 – 5 nm, a surface roughness Ra of 0.1 – 0.3 nm can be made by forming an SiO₂ film on substrate 2. For example, a duration of immersing substrate 2 in a mixture solution is changed, and concentration of the mixture solution is also adjusted, depending on the value of surface roughness Ra of substrate 2 after conducting the polishing step, to obtain a surface roughness Ra of 0.1 – 0.3 nm.

[0063] In addition, an SiO₂ film was used as metal oxide film 3 in Example 1, Example 2 and Example 3, but the metal oxide film of the present invention is not limited to an SiO₂ film. The case where an oxide film containing at least one selected from the group consisting of the foregoing plural metals is used also produces the same action and effect as in the case where an SiO₂ film is used. For example, a duration of immersing substrate 2 in a mixture solution is changed, and concentration of the mixture solution is also adjusted to obtain a surface roughness Ra of 0.1 – 0.3 nm.

CLAIMS

1. A method of manufacturing a magnetic recording medium substrate, comprising the steps of:
polishing a surface of a disk-shaped substrate, and
forming a metal oxide film on the substrate surface having been subjected to the polishing step
via a liquid phase deposition process to prepare the magnetic recording medium substrate.
2. The method of Claim 1, comprising the step of:
polishing the substrate surface in the polishing step until surface roughness Ra reaches 0.3 – 5
nm.
3. The method of Claim 1 or 2,
wherein the metal oxide film is a silicon dioxide film.
4. The method of Claim 1 or 2,
wherein the metal oxide film is an oxide film comprising at least one selected from the group
consisting of Si, Ti, V, Mn, Ni, Zn, Ge, Y, Zr, Nb, Sn, Sb, Ba, Ta and W.
5. The method of any one of Claims 1 – 4,
wherein the substrate is a glass substrate or an aluminum substrate.
6. The method of any one of Claims 1 – 5,
wherein the step of forming the metal oxide film comprises the processes of:
immersing the substrate having been subjected to the polishing step in an aqueous solution,
and
hydrolyzing a metal-fluoro complex in the aqueous solution to form the metal oxide film on
the surface of the substrate having been subjected to the polishing step.
7. A magnetic recording medium comprising:
a disk-shaped substrate having a surface roughness Ra of 0.3 – 5 nm,
a metal oxide film formed on a surface of the substrate, and
a magnetic film further formed on the metal oxide film.